國立東華大學

Department of Physics
National Dong Hwa University, 1, Sec. 2,
Da Hsueh Rd., Shoufeng, Hualien, 974, Taiwan

General Physics I, Final 1
PHYS10400, Class year 103
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SN:_____, Name:_____

ABSOLUTELY NO CHEATING!

Note: This is a close-book examine. You can use pencil or any pen in answering the problems. Dictionary and Calculators are allowed.

The followings are some useful mathematics you may use without proof in answering your problems.

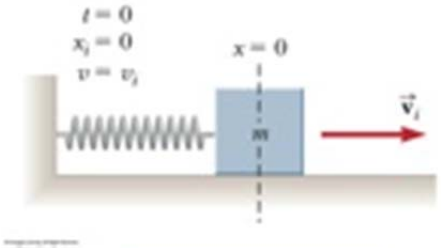
$\sin x = x - \frac{1}{3!}x^3 + \frac{1}{5!}x^5 - .....$. Time average $\overline{x(t)^n} = \langle x(t)^n \rangle = \frac{1}{T}\int_0^T x(t)^n dt$

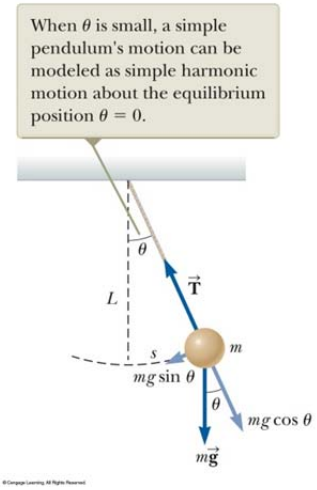
For a second order differential equation, $\frac{d^2x}{dt^2} + ax = 0$ the general solution of this equation is $x(t) = x_0 \cos(at + \phi)$, where x_0 is the maximum, and ϕ is the phase angle.

$N_A = 6\times10^{23}$, R = Gas constant= 8.31 J/mole K, room temperature =300K, 1atm=1.01×105 Pa.

$\overline{v_x} = \frac{v_{rms}}{\sqrt{3}}$ for ideal gas.

Problems (7 Problems, total 120%)





1. **Harmonic Oscillation (20%):** (a, b) Refer to the two figures to the right, (a, upper) write down differential equations that can describe the motion for a mass ***m*** attached to a spring of force constant ***k***; and (b, lower) the same mass attached to a pendulum of length ***L***. In both cases, use the given parameters. In the upper case, describe the motion in terms of its displacement ***x***; while in the lower case, describe its motion in terms of the angle ***θ***. (c) If we treat the pendulum as a simple harmonic oscillator and look at only the horizontal displace ***s*** at small angle, what will the equation look like?

2. **Standing wave (20%)**: To generate a standing wave between two vertical walls separate by a distance L, you set up a wave from the left wall traveling with a speed to the right, and from the right wall traveling with the same speed to the left. It is possible to generate a standing wave between the two walls. (a) Write down the wave functions for both the right-traveling and left-traveling waves. (a) Derive the wave function to describe the standing wave. (c) What are the conditions (or the x-position) to have a node?

3. **<u>Thermaldynamic 1st law</u> (20%):** A cabin of volume V is filled with air (which we consider to be an ideal gas) at an initial low temperature T_1. After you light up a wood stove, the air temperature increases to T_2. What is the resulting change in internal energy (E_{int}) of the air in the cabin?

4. **<u>Adiabatic Process</u> (20%):** Why constant pressure specific heat (C_p) id bigger than constant volume specific heat (C_v)? (b) Prove that for an adiabatic expansion of an ideal gas, $PV^{\gamma}=constant$, where $\gamma = C_p/C_v$.

5. **<u>Gravitation Force</u> (20%):** Suppose you drill a hole on the earth from pole to pole (say, from the North Pole to the South Pole). (a) What will happen when you drop an object from the North Pole; will the object reach the South Pole? (b) If the object will drop the South Pole, how long does it take to reach the other side? You can assume the earth has a radius R, density ρ.